FOSSIL FLORA OF THE DRYBROOK SANDSTONE IN THE FOREST OF DEAN, GLOUCESTERSHIRE

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FOSSIL FLORA OF THE DRYBROOK SANDSTONE IN THE FOREST OF DEAN, GLOUCESTERSHIRE

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SYNOPSIS

Descriptions of the fossil plants including *sporae dispersae* found in the Drybrook Sandstone (Mississippian) at Hazel Hill in the Forest of Dean, Gloucestershire are given. The most frequently occurring species are *Lepidophyllum fimbriatum* Kidston, *Scutellocladus variabilis* gen. et sp. nov. and *Diplopteridium holdeni* sp. nov. The spores belong to nineteen genera including three new species. A close comparison can be made between this flora and the flora of the Lower Brown Limestones at Diserth in North Wales and the age, judging from the plants, is that of the Calciferous Sandstone of Scotland. Palaeozoological evidence however supports a considerably later age.

INTRODUCTION

The fossil plants described below were collected by Dr. H. S. Holden, Mr. F. M. Wonnacott, Mr. T. D. West, Mrs. C. J. Croucher and Mr. Keith Allen. Most of the specimens described are preserved in the British Museum (Nos. V.42428–43004, V.42048, V.42049), a few are in the Geological Museum, University of Birmingham (B.U. 800–804) while one is in the Hunterian Museum, University of Glasgow (No. Pb.3452). Preparations of the *sporae dispersae* isolated from the sandstone are now in the British Museum (Nos. V.43700–43734). In addition we have been kindly allowed to examine a collection made by members of the staff of the Geological Department, Kingston Technical College.

The specimens were all collected from a bed of fine sandstone with a grey to pink coloration in the Hazel Hill Quarry (Grid reference 32/646184) near Puddlebrook in Gloucestershire. The organic matter of the original plants is in the form of a black powder and only in exceptional cases (a few lepidophytes) is a cuticular membrane preserved. The forms of the plants are retained as a fine impression on the sandstone which is stained a brownish colour where it was in contact with the plant material. This helps to show up the shapes of the plants in photographs taken on orthochromatic plates.

The rock also contains somewhat poorly preserved spores. The *sporae dispersae* were isolated by macerating small fragments of the plant-bearing rock in cold concentrated hydrofluoric acid for about a week. The residue was washed free of the acid and the organic matter containing the microfossils was further separated by the swirling method (Funkhouser & Evitt, 1959 : 373). The material thus concentrated was directly mounted in glycerine jelly. Canada balsam and chloral hydrate were also found suitable for mounting. In favourable cases, grains were individually picked out and mounted for study. Staining with Safranin was found useful especially in case of lightly coloured spores. In view of the rather sparse spore population several macerations were made and nearly fifty slides were examined for the identification of spores. The number of better preserved and identifiable specimens is given in the description of each species. The system of classification used here is that of Potonié & Kremp (1955).

One of the most frequently occurring fossils, a lepidophyte sporophyll, *Lepidophyllum fimbriatum* Kidston has been described and figured by Allen (1961) and others under the name of *Lepidostrobophyllum fimbriatum* (Kidst.) but so far the generic name *Lepidostrobophyllum* has no valid basis and it is hoped that this nomenclatural confusion may be cleared up. The only animal fossil found associated with the plants is a Conulariid organism almost certainly of marine origin, which suggests that the sediments containing the plants were deposited near the sea in a lagoon or estuary.

In the earliest account of the geology of this area and on the one-inch, Old Series, sheets of the Geological Survey (43 S.E., 43 S.W. and 35) of the Forest of Dean, the Drybrook Sandstone is stated to be of Millstone Grit age. In the Geological Survey Memoir Trotter (1942 : 15, 16) divides the Drybrook Sandstone into upper and lower parts separated by the Drybrook Limestone or its equivalent. In the north the Coal Measures overlap, unconformably, the Lower Drybrook Sandstone. At Hazel Hill the sandstone rests on Limestones referred to zones C_2S_1 of the Avonian zone sequence and is overlain unconformably by the Coal Measures (Sibly & Reynolds, 1937 : 25, 37). Crookall (1939 : 72) assigns some obscure plant remains in the Drybrook Sandstone to ?*Cyclostigma*, a genus of Devonian plants, but they might well be the remains of a Carboniferous lycopod.

In the account that follows, descriptions are given of the most complete and identifiable specimens.

SYSTEMATIC DESCRIPTIONS

Genus *SCUTELLOCLADUS* nov.

Diagnosis. Stems bearing narrow lanceolate, acuminate, falcate leaves. Leaves spirally arranged, almost contiguous, rhomboidal in section near their bases. On the smallest branches the leaves are more widely separated. On small branches which have lost their leaves the leaf scars are elliptical and level with the surface of the stem. A punctiform cicatrule is present in the centre of the scar. There are no persistent leaf bases or cushions and no evidence of a ligule or parichnos.

Type species. *Scutellocladus variabilis* sp. nov.

Scutellocladus variabilis sp. nov.

(Pl. 19, figs. 1–6)

Diagnosis. As for the genus.

Syntypes. B.M.N.H. Nos. V.42433, V.42477, V.42538, V.42558.

Locality. Hazel Hill Quarry, Puddlebrook, Forest of Dean, Gloucestershire.

Horizon. Drybrook Sandstone. Mississippian.

Description. There is a number of examples of small branches of a plant with the appearance of a lycopod. Their stems vary in thickness from 1 mm. to 8 mm., some having their leaves still attached (Pl. 19, figs. 1, 2, 3, 5, 6) and some from which the leaves have fallen (Pl. 19, fig. 4). Where branching is seen it is dichotomous. The leaves vary from about 9 mm. to 5 mm. in length and from 2 mm. to 0·5 mm. in breadth. The leaves were acuminate, falcate and rhomboidal in section judging from the shape of their area of attachment to the stem (Pl. 19, fig. 1*a*). They were closely set on the stem in a spiral phyllotaxy. On one branch (Pl. 19, fig. 2), which is presumably at a later stage of development, the bases of the leaves which are still attached exhibit a narrow central vertical groove, are more widely spaced and are subcircular to elliptical in shape. The groove no doubt represents the vascular strand in the leaf base. On the smaller branches the leaves are attached by bases more elongated vertically and the scars are vertically elongated ellipses (1·8 × 1·5 mm.) with a central punctiform cicatrule (Pl. 19, fig. 4). The scar is flush with the surface of the branch and there is no elevated leaf base or cushion. This is evident when the profile of the branch is studied where it is seen to be almost straight. The scars measure about 1 mm. long by 0·7 mm. wide on the very smallest branches (Pl. 19, fig. 6).

There is no evidence of a ligule or parichnos on the leaves or on the defoliated branches. The complete absence of a persistent leaf cushion is a marked characteristic and the base of the leaf is not decurrent. There are some lycopod-like stems described by Radchenko (1956 : 199, pl. 36, figs. 1, 2 ; 1957 : 50, pl. 3, figs. 2, 3) under the name *Tomiodendron ostrogianum* (Zal.) which at first sight seem to resemble our fossils : but on closer examination it is clear that they had projecting persistent bases, in many cases decurrent, with a definite leaf-scar at the top of the cushion.

In addition to the compressions of small leafy branches assigned to *Scutellocladus variabilis* there are several examples (B.M.N.H., Nos. V.42459, V.42551, V.42557, V.42559) in which nothing but the cuticle remains in the form of a perforated lamina similar to the cuticles of *Bothrodendron tenerrimum* from the Moscow basin but lacking any trace of the cuticular linings of the ligular pits characteristic of that species. These Hazel Hill cuticles are from branches from about 8 mm. to over 13 mm. in diameter and may belong to *S. variabilis*.

Genus ***LEPIDOPHYLLUM*** Brongniart

Lepidophyllum cf. ***fimbriatum*** Kidston

(Pl. 20, figs. 18–20)

In addition to typical examples of *L. fimbriatum* (Allen, 1961 : 225) there is a number of lepidophyte leaves which are much longer, some reaching more than 6·5 cm. and about 6 mm. at the broadest part of the base (Pl. 20, fig. 20). The leaves taper very gradually to an acute apex. A single vein is visible in the middle and, while several have a smooth margin, two show rather widely spaced lateral hairs (Pl. 20, fig. 18) smaller than those of *L. fimbriatum* but of the same kind. If a sporangium had been present it must have been less than 6 mm. in width. A slight transverse cleft can be seen in one or two (Pl. 20, fig. 19) which might indicate the presence of a ligule. There is no film of carbonaceous matter at their proximal end as dense as that found on *L. fimbriatum* as described by Kidston (1883 : 543).

One can merely speculate as to the nature of these leaves. Perhaps they were the foliage leaves of the plant, either microsporophylls, sterile bracts of a strobilus, or intermediates between sporophylls and leaves.

There are some indubitable specimens of *L. fimbriatum* which measure only 8 mm. at the widest point and in the region where the sporangium was probably present are only 5 mm. wide.

Cf. ***Stigmaria***

(Pl. 19, fig. 7)

Two or three impressions of which the largest is shown in Pl. 19, fig. 7 are in the collection. They exhibit an extended smooth surface with one or more circular scars ranging from about 10 mm. to 12 mm. in diameter, each with a small central elevation. There scars closely resemble those on a *Stigmaria*. A large part of the surface shown uppermost in the figure has no such scars. In the Manchester Museum there is a similar specimen (Manch. Mus. CWM.23) which consists of a smooth surface, about 5 × 3 cm., on which there are two scars of the same kind. This specimen is from the Lower Brown Limestone at Diserth in North Wales. Another specimen from the same locality consists of a lepidophyte axis (Manch. Mus. LL.1190) 28 cm. long which tapers from 9·5 cm. in width at the base to 4 cm. at the top; on which at the lower end there are similar large stigmarioid scars and on its upper two-thirds numerous regularly arranged small indentations or scars which are obviously the marks of leaf traces. As no leaf traces can be seen on the surface round the large scars it is unlikely that the large scars represent branch scars. These specimens are possibly parts of the base of a lepidophyte of comparable size to the "Naples tree" *Lepidosigillaria whitei* (Kräusel & Weyland, 1949 : 148) which has a slightly bulbous base with stigmarioid scars to which rooting appendages were attached.

Genus ***DIPLOPTERIDIUM*** Walton

Diplopteridium holdeni sp. nov.

(Pl. 20, figs. 8–15)

Diagnosis. Fronds tripinnatifid, from 10 cm. to 20 cm. long, ultimate divisions about 0·5 mm. in width. Main rachis from 2 mm. to 3·5 mm. broad at base; forking equally into two main divisions. Pinnae borne on the two divisions of the frond and on the rachis below the fork. Some fronds have a naked rachis in the angle of the fork. Its first dichotomy is at right angles to the plane of the frond.

Holotype. B.M., V.42453.

Paratypes. B.M., V.42474, V.42487, V.43004.

Locality. Hazel Hill Quarry, Puddlebrook, Forest of Dean, Gloucestershire, England.

Horizon. Drybrook Sandstone; Mississippian.

DESCRIPTION. The most noticeable and one of the most frequently occurring species found in the Hazel Hill quarry beds is a tripinnatifid frond which bears a close similarity to *Diplopteridium teilianum* (Kidston) which was found in beds assigned to the Upper Black Limestone near Prestatyn in North Wales. The fronds are, however, much smaller (Pl. 20, figs. 8–15) and the ultimate divisions of the pinnules narrower than those of *D. teilianum*. As far as one can judge from the fragments the fronds were probably from 10 cm. to 20 cm. in length and the main rachis, which in the specimens examined ranges from 2 mm. to 3·5 mm. in width, forked into two equal divisions in the middle of the frond. Near the proximal end of the frond (Pl. 20, fig. 9) the pinnae are small with few divisions and are opposite but higher up they increase in size and complexity and are alternate. They appear in many instances to have had their principal plane facing the rachis (Pl. 20, figs. 8, 10) so that as a result of compression the pinna at first sight resembles a *Rhacopteris* pinnule of the *R. petiolata* type and *Rhacopteris geikiei* Kidston (1923*a* : 218, text-fig. 11). The main rachis in one specimen (Pl. 20, fig. 9) appears to have been rugose. The arrangement of the pinnae in relation to the forking of the main rachis and their degree of subdivision is similar to that found in *D. teilianum*. Towards the ends of the two main divisions of the frond the pinnae become smaller and simpler and in the entire apex seen in Pl. 20, fig. 11 the rachis terminates in a single spatulate division.

Evidence for the presence of the fertile part of the frond, in the same position as that in specimens of *D. teilianum* (Walton, 1926 : 213, pl. 17, figs. 17–19), is afforded by one specimen (Pl. 20, fig. 8) where a bare rachis is seen as a continuation of the main rachis of the frond in the angle between the two divisions of the pinna-bearing parts of the frond. Careful examination reveals that the first forking of this presumably fertile rachis was a dichotomy at right angles to the plane of the frond. The presence of this structure in the angle of the fork supports the assignment of this plant to the genus *Diplopteridium*. Parts of the two divisions of a considerably larger frond (Pl. 20, fig. 13) have, situated between them, portions of a naked branching system (Pl. 13, fig. 13*x*) which probably represents the fertile part of the frond.

Genus ***SPHENOPTERIS*** Brongniart

Sphenopteris obfalcata Walton

(Pl. 20, figs. 16, 17)

Several fragmentary pieces of this frond from Hazel Hill (Pl. 20, figs. 16, 17) exhibit collectively features which justify identification with the type of this species from the Upper Black Limestones in N. Wales (Walton, 1931 : 363). The frond appears to have been at least tripinnatifid with a tendency for the pinnae to be opposite. The ultimate divisions and the form of the pinnae bear some resemblance to those of *Diplopteridium* but the ultimate divisions are more spatulate. There are several genera such as *Sphenopteris, Sphenopteridium, Spathulopteris* and *Rhodea* which have much divided fronds with fine ultimate segments and it is often difficult to decide to which genus such specimens as these should be assigned.

Sphenopteris cuneolata L. & H.

(Pl. 21, fig. 21)

Four incomplete specimens of a frond resembling *Sphenopteris cuneolata* L. & H. (Lindley & Hutton, 1837, pl. 214) occur in the collections from Hazel Hill. Kidston (1923 : 156) states that the type specimen is lost. The largest fragment (Pl. 21, fig. 21) probably represents part of a frond below the main fork, for the pinnae seem to get larger towards its distal end and are opposite. The rachis was evidently about 2 mm. thick as in Lindley & Hutton's figure. A smaller fragment (V.42048) with a rachis about 1·5 mm. thick has its pinnae alternately attached as in the upper divisions of the type. In the type and in the specimens from Hazel Hill several of the pinnae appear to be inaequilateral. This is due to folding of the pinnae as explained in the description of *Diplopteridium holdeni*. No venation is visible on the pinnules which have a finely striated surface. The base of the pinna is shortly decurrent on the rachis. The chief differences which exist between these specimens and the drawing of the type lie in the greater breadth of the frond and the wider spacing of the pinnules in the former. Kidston (1923 : 156) includes in the species a specimen of a frond from the Oil Shales, Calciferous Sandstone Series in Hailes Quarry near Edinburgh which differs very obviously from the type as figured by Lindley & Hutton (1837, pl. 214) in having definitely katadromic venation and in being irregularly and slightly lobed and unlike the type which, in common with the Hazel Hill specimens, has pinnately divided pinnae.

In view of the loss of the holotype the specimen described here (Pl. 21 fig. 21) is selected as the lectotype of *Sphenopteris cuneolata* L. & H.

Genus ***ARCHAEOPTERIDIUM*** Kidston

Archaeopteridium tschermaki (Stur)

(Pl. 21, fig. 22)

One specimen (B.U. 802) which we assign to this species (Pl. 21, fig. 22) consists of a clear impression on the fine sandstone of three pinnae attached to a piece of rachis. The shape and venation of the pinnules match exactly those of *Archaeopteridium tschermaki* (Stur) Kidston (1923 : 182) which has records in Britain ranging from the Limestone Coal Group down to the Oil Shale Group.

A second specimen (V.42498) which has smaller, more rounded pinnules or lobes with the same type of venation may also, perhaps, be assigned to this species.

FRUCTIFICATIONS

A considerable number of detached fructifications occur on the surfaces of the sandstone. Two types are of frequent occurrence and are in most cases on the same surfaces which have impressions of *Diplopteridium* fronds ; one must be referred to *Telangium* sp., the other seems to consist of bunches of cupules.

Telangium sp.

(Pl. 21, figs. 23–26)

There are several examples of fructifications consisting of a number of disc-like bodies connected in some instances by slender axes and each bearing numerous, pointed fusiform sporangia (Pl. 21, figs. 23–26). The individual sporangia appear to be about 1·3 mm long. There is a close resemblance in form and size between these fructifications and the *Telangium* found in connection with *Diplopteridium teilianum* (Kidston) (Walton, 1931, pl. 23, figs. 1, 3, 4). The sporangia of the *Telangium* found associated with *Sphenopteris affinis* L. & H. are from 2·5 mm. to 3·5 mm. in length while those associated with *Sphenopteris bifidum* are about 2 mm. long (Kidston, 1924 : 446, 454).

Calathiops sp.

(Pl. 21, figs. 27–29)

There are a number of examples of fructifications which consist of bunches of elongated structures which are considerably larger than the sporangia in the *Telangium* type. They probably were ovuliferous for in at least one example one of the bunches distinctly resembles an encupuled seed (Pl. 21, fig. 27*c*). Similar fructifications have been described by Kidston (1883 : 539, pl. 31, fig. 11) from the Cementstone Group in Liddesdale where they were found in masses in the shales. The name *Schützia* was later applied by Kidston (1924 : 424) to microsporangiate fructifications. We have decided, however, to include these fructifications of an indeterminate nature in the genus *Calathiops* of Goeppert.

Very probably these *Telangium* and *Calathiops* types represent pollen-bearing and ovuliferous organs of *Diplopteridium* as they are abundant on the same surface as the fronds of the latter.

SPORAE DISPERSAE

1. ***Leiotriletes sphaerotriangulus*** (Loose) Pot. & Kr.

(Pl. 21, figs. 30, 31)

Seven specimens ranging in size from 35 μ to 55 μ are closely similar to *Leiotriletes sphaerotriangulus* (Loose) Pot. & Kr. (1955 : 41). The trilete rays are distinct and almost reach the spore margin.

2. ***Punctatisporites minutus*** Kos.

(Pl. 21, figs. 32–34, ?35–37)

Small forms agreeing in size range with *P. minutus* Kosanke (1950 : 15) are not infrequent. The spore figured by Potonié & Kremp (1955, pl. 11, fig. 120) although smaller than the known size range (25–35 μ) seems indistinguishable from our specimens. The rays, in the present examples, are often eccentric and irregular. The exine usually shows an infrasculpture.

There are several other specimens (size range 18–40 μ) of a similar generalized pattern but having a thinner laevigate exine and thin or indistinct rays (Pl. 21, figs. 35–37). Although these specimens are provisonally placed under *P. minutus*, they might possibly belong to *Calamospora*.

Punctatisporites subobesus sp. nov.

(Pl. 21, figs. 38–42)

Diagnosis. Size range 45–80 μ (30 specimens); circular-subcircular; rays simple, more than $\frac{1}{2}$ spore radius; exine commonly split open along the trilete mark to form a $\pm$ wide triangular fissure; folding along fissure occasional; exine up to nearly 4 μ thick, $\pm$ translucent, smooth to infrasculptured; folds uncommon.

Holotype. Pl. 21, fig. 40; 70 μ. B.M., V.43701.

Comparison. Spores similar to *P. obesus* (Loose) Potonié & Kremp (1955 : 43) in habit but distinguishable by their smaller size and longer trilete rays or fissure. Pl. 21, figs. 39–42 represent different degrees of the split trilete area. *P. fissus* Hoffmeister, Staplin & Malloy (1955 : 393) and *P. debilis* Hacquebard (1957 : 308) are distinguishable by their smaller size, thinner exine, shorter trilete area and granular sculpture.

4. ***Punctatisporites*** spp.

(Pl. 21, fig. 43)

The collection contains several specimens of *Punctatisporites* which cannot be specifically identified owing to their bad preservation or insufficient number. These spores range in size from 45 μ to 90 μ and may include more than one species. The spore in Pl. 21, fig. 43 has simple rays which reach the margin.

5. ***Calamospora*** sp. cf. ***C. mutabilis*** (Loose)

(Pl. 22, fig. 44)

Size range 82–115 $\times$ 30–43 μ (6 specimens), all folded into boat-shaped form; trilete mark seen only in one case (Pl. 22, fig. 44), rays thin, simple, longest ray 33 μ, a little more than $\frac{1}{2}$ spore radius; exine moderately thin, smooth to faintly infra-punctate, yellow to brown in colour, with no difference in structure or colour in the contact area.

The spores, in most of their features, are comparable with *Calamospora mutabilis* (Loose) (see Potonié & Kremp, 1955 : 49 and Bhardwaj, 1957 : 82).

6. ***Granulatisporites tenuis*** sp. nov.

(Pl. 22, figs. 45, 46)

Diagnosis. Size range 17–25 μ (10 specimens), triangular to roundly triangular, rays distinct, occasionally with thin lips, reaching spore margin; exine crowded with very minute grana, about 20 grana between two rays on the margin; ornament present on rays.

HOLOTYPE. Pl. 22, fig. 45 ; 20 μ. B.M., V.43708.

REMARKS. The species is distinguished by its small size, minute grana and long rays bearing similar ornament.

7. *Granulatisporites* sp. cf. *G. orbiculus* (Pot. & Kr.)

(Pl. 22, figs. 47, 48)

Size range 24–35 μ (12 specimens), triangular to roundly triangular ; rays extending almost up to spore margin ; preservation of ornament poor, grana apparently somewhat irregular and partly coalescent. Nearest comparable species is *Granulatisporites* (*Cyclogranisporites*) *orbiculus* (Pot. & Kr) Potonié & Lele (1959).

8. *Cyclogranisporites amplus* McGregor

(Pl. 22, figs. 49–51)

Size range 50–90 μ (16 specimens) ; circular, trilete rays not always seen, $\frac{2}{3}$ spore radius or more ; ornament of dense grana of variable size and shape, grana usually less than or up to 1 μ in diameter, over 100 grana at the margin, exine thickness variable, secondary folds common.

The present specimens fall within the size range of *C. amplus* McGregor and agree in most respects with it. It may be added that the ornament in *C. amplus* also appears to be rather variable as in the present forms (cf. McGregor, 1960, Pl. 11, fig. 8).

9. *Cyclogranisporites* sp.

(Pl. 22, fig. 52)

Size range 17–40 μ (20 specimens) ; circular, trilete mark weak, often not visible, when present rays $\frac{3}{4}$ spore radius or longer, ray ends often indistinct ; exine thin, with frequent compression folds ; ornamentation of densely set minute grana, grana ± variable in shape and size, often obscure on the equator ; state of preservation unsatisfactory.

10. *Planisporites minimus* McGregor

(Pl. 22, figs. 53–55)

Size range 25–30 μ (4 specimens), triangular to nearly circular ; rays indistinct, apparently long ; ornament of minute coni or fine hairy spinules.

The few specimens in the present preparations do not represent the overall size range. They can, however, be assigned to *Planisporites minimus* McGregor (1960 : 29, pl. 11, fig. 9) with which they agree most. It may also be remarked that the two species *P. minimus* McGregor and *P. delucidus* McGregor (1960 : 30, pl. 11, fig. 16) are so similar in characters that they would appear to fall within the size range of a single species.

11. ***Planisporites*** sp. cf. ***P. granifer*** (Ibr.)

(Pl. 22, fig. 56)

Single specimen ; 112 × 100 μ, triangular, corners rounded ; triangular fold in the centre ; exine with ± sparsely set short coni. The specimen is slightly larger but is comparable with *P. granifer* (Ibr.) Knox (cf. Potonié & Kremp, 1955 : 71 ; 1960 : 38).

12. ***Verrucosisporites*** sp.

(Pl. 22, fig. 57)

Specimens referable to *Verrucosisporites* are too few to justify specific determinations. Pl. 22, fig. 57 represents an example somewhat comparable with *V. donarii* Potonié & Kremp (1955 : 67).

13. ***Camptotriletes*** sp.

(Pl. 22, fig. 58)

Single specimen, 105 × 90 μ, roundly triangular, rays $\frac{2}{3}$ spore radius, ornament of verrucae up to 9 μ long and up to 8 μ broad, often connected to form crested ridges. The ornament of the exine supports the assignment of the specimen to *Camptotriletes*.

14. Cf. ***Convolutispora*** sp.

(Pl. 22, fig. 59)

A few specimens, showing somewhat convoluted ridges, are probably referable to *Convolutispora*. The specimen in Pl. 22, fig. 59 recalls *C. tessellata* H. S. & M. of Butterworth & Williams (1958, pl. 2, figs. 17, 18).

15. ***Microreticulatisporites*** cf. ***cribellarius*** (Horst)

(Pl. 22, figs. 60, 61)

Size range 40–55 μ (10 specimens), roundly triangular, rays distinct, extending up to the spore margin ; reticulum imperfect, ± indistinct ; lumina very small, muri low and barely evident at the margin.

The specimens are closely comparable with and probably indistinguishable from *Microreticulatisporites cribellarius* (Horst) Potonié & Kremp (1955 : 97).

16. ***Microreticulatisporites*** spp.

(Pl. 22, figs. 62, 63)

(i) Pl. 22, fig. 62 :

Size range 65–78 μ (3 specimens) ; triangular to roundly triangular, thick rays almost reaching the equator, gnarled ; muri 1–2 μ wide, not very high, lumina about equal to or slightly narrower than the width of muri ; reticulum imperfect, apparently coarse, outline minutely undulating, about 20 curvatures between two rays at the margin, exine 2 μ thick.

(ii) Pl. 22, fig. 63 :

Size range 20–37 μ (a few specimens) ; triangular to $\pm$ circular ; rays indistinct, about $\frac{2}{3}$ spore radius ; muri about 1 μ thick, close, irregular, anastomosing but no definite reticulum, margin minutely undulating, about 15–20 curvatures between two rays at the margin.

17. ***Dictyotriletes*** sp.

(Pl. 22, fig. 64)

Single specimen, probably comparable with *D. falsus* Potonié & Kremp (1955 : 109 ; Love, 1960, pl. 1, fig. 8).

Remarks. There are a few other ill-preserved specimens with somewhat projecting muri which are referable to *Reticulatisporites*. Besides these, one or two specimens may perhaps belong to *Knoxisporites*.

18. ***Lycospora*** cf. ***bracteola*** Butt. & Will.

(Pl. 22, fig. 65)

Size range 45–55 × 40–48 μ (6 specimens), width of cingulum of a spore often not uniform ; exine faintly granular, cingulum with much finer granules, visible only under high magnification.

The specimens are comparable with *L. bracteola* Butterworth & Williams (1958 : 357).

19. ***Lycospora*** spp.

(Pl. 22, figs. 66–69)

The genus is, on the whole, very poorly represented in numbers of spores, although more than one type is present. A few specimens with a narrow cingulum and a thickened inner zone (crassitudo) represents one type (Pl. 22, fig. 66). Another type (Pl. 22, fig. 67) somewhat recalls *L. granulata*. The form in Pl. 22, fig. 68 has a wider cingulum and a narrower inner crassitudo. The ornamentation of the cingulum varies from minute grana to short, narrow bacula. The specimen in Pl. 22, fig. 69 has a narrow membraneous cingulum, without a crassitudo. Types shown in Pl. 22, figs. 67–69 are solitary specimens.

20. ***Anulatisporites anulatus*** Pot. & Kr.

(Pl. 22, figs. 70, 71)

Size range 37–68 × 30–53 μ (12 specimens) ; usually oval, occasionally subtriangular ; cingulum $\pm$ $\frac{1}{3}$ total spore radius, width often not uniform, outer margin smooth ; trilete mark indistinct to invisible, exine of central area and cingulum faintly infrasculptured.

The specimens bear close similarity to *A. anulatus* (Potonié & Kremp 1956 : 112). A few of them (Pl. 22, fig. 71), provisionally included under this species, have a comparatively narrower cingulum.

21. ?*Anulatisporites* sp.

(Pl. 22, fig. 72)

Single specimen ; 90 × 76 μ ; oval ; central area nearly triangular, thin ; cingulum 25 μ wide, roughly equal to diameter of central area ; a peripheral thickening (limbus?) about 2 μ wide evident ; inner margin of cingulum also similarly thickened (about 2 μ) ; exine laevigate to infrasculptured ; trilete mark not visible.

REMARKS. The essentially sculptureless cingulum, its smooth outline and apparent absence of a trilete mark favour the assignment of this specimen to *Anulatisporites*. However, a peripheral limbus-like thickening in *Anulatisporites* is hitherto unknown. The dark points seen on the cingulum in the photograph are due to foreign matter on the spore.

22. *Densosporites* sp.

(Pl. 23, fig. 73)

Single specimen ; 56 × 48 μ ; subcircular ; central area infrapunctate ; cingulum 13 μ wide, roughly equal to radius of central area, rugose in appearance owing to presence of irregular warts of variable size, specially towards the inner margin of cingulum where they appear to form a ± continuous, narrow, thickened ill-defined zone. The cingulum towards the periphery is finely wrinkled ; outline nearly smooth ; trilete mark invisible.

23. Cf. *Cirratriradites* sp.

(Pl. 23, fig. 74)

Single specimen ; 70 × 48 μ ; triangular ; central body 40 × 30 μ, triangular, distinct ; equitorial zone thin, about 12 μ wide, outline minutely crenulate ; radial striations visible ; trilete mark clear, rays extending beyond the central body ; exine of central body and zone minutely granular-punctate.

The preservation of the spore is poor but its appearance supports an attribution to *Cirratriradites*.

24. *Endosporites* sp.

(Pl. 23, fig. 75)

Single specimen, 52·5 μ ; subcircular ; body 36 μ, circular, thin-walled ; bladder nearly 10 μ wide, ± ½ radius of body, infrareticulate, with radial folds ; outline smooth ; trilete mark not seen.

25. *Remysporites drybrookensis* sp. nov.

(Pl. 23, figs. 76–81)

Cf. Radforth & McGregor, 1956 : 27, pl. 1, fig. 7.

DIAGNOSIS. Size range 70–155 × 70–128 μ (50 specimens) ; usually oval in outline, occasionally circular ; central body large, 60–115 × 60–98 μ, distinct, often denser than the bladder, smooth, with frequent cracks, folds uncommon; bladder somewhat thick, apparently attached to the proximal side of body, smooth to faintly infrapunctate or infragranulate, folds uncommon; trilete mark often not evident, rays simple, often eccentric, ± half the length of the longer axis of the body.

HOLOTYPE. Pl. 23, fig. 76; 108 × 97 μ. B.M., V.43719.

REMARKS. The spores are referable to *Remysporites* Butt. & Will. *sensu* Potonié (1960 : 72). They lack good proximo-distal orientation, with the result that the bladder may be more or less asymmetric and the trilete mark eccentric. The bladder width (compensated) ranges between 8–32 μ and is approximately $\frac{1}{4}$–$\frac{1}{12}$ of the longer axis of the body. The specimens, however, show all variations between the two extremes and may, therefore, be placed under the same species. The central body is variously cracked. There is often a concentric and ± continuous fissure along the margin of the body which produces a lighter zone between the body and the bladder (Pl. 23, figs. 76–80). In many cases, however, this fissure is absent (Pl. 23, fig. 81) and the crack is evidently not an original feature.

The present spores are distinguished from the known species of *Remysporites* (Butterworth & Williams, 1958; Staplin, 1960) by their consistently smooth and relatively thick body and bladder and the lack of secondary folds.

26. Cf. ***Remysporites*** sp.

(Pl. 23, fig. 82)

Two or three poorly preserved specimens. A more complete one (Pl. 23, fig. 82) measures 175 μ; body dense, 100 μ; bladder thin, as wide as the radius of body, folded over the central part; ornament obscure; trilete mark not seen. The spore recalls *Remysporites* in size and appearance but the bladder is somewhat broader (cf. Butterworth & Williams, 1958 : 386).

27. SPORAE INSERTAE SEDIS

Pl. 23, fig. 83: Single specimen; 40 μ; triangular; central body convexly triangular, 25 μ; apparently enclosed by a rather thick structure (?capsula), outline of spore irregularly lobed; surface of spore laevigate but somewhat irregularly thickened at places to form small sinuous ridges (seen only by proper adjustment of focus). Spore pale yellow, transparent; trilete mark distinct, rays almost reaching equator of central body.

Pl. 23, fig. 84: Single specimen; 53 μ; roundly triangular; equitorial ridge (? cingulum) nearly 2·5 μ wide, about $\frac{1}{5}$ radius of central area; rays distinct, open, almost reaching margin of central area; exine of central area with irregular, large mounts; outline undulated.

THE AGE OF THE DRYBROOK SANDSTONE

There is a close lithological resemblance between the plant-bearing sandstones at Hazel Hill and the basement beds of the Lower Brown Limestone at Moel Hiraddug at Diserth, North Wales. In both, the sandstone is light coloured and friable and contains, associated with the plants, *Conularia* or Conulariid fragments, two from Hazel Hill (B.M., V.42431 and B.U. 800*a*) and numerous examples from Diserth (Manchester Museum, Cwm 3–28). There is also the occurrence in both places of specimens of smooth axes with stigmarioid scars which hitherto have not been observed elsewhere.

At the Diserth locality several examples of the fucoid *Chondrites plumosus* Kidston occur in association with abundant remains of *Lepidophyllum fimbriatum*, Kidston. These two fossils are also recorded by Kidston from the Cementstones at Glencartholm in the Borders. Among the specimens from Hazel Hill (e.g. B.M., V.42449) there are examples of a fucoid which consists of filaments 0·3 mm. in diameter and up to 9 cm. in length.

These facts suggest that the Hazel Hill and Diserth sediments were deposited in lagoons or estuaries near the sea and were of the same age as the lower part of the Calciferous Sandstone Series in the Borders.

The spores, on the whole, suggest a relatively simple and old type of assemblage in which *Punctatisporites* constitutes nearly half of the spore population and the *Azonotriletes* forms occur in far greater numbers than the *Zonales*. Very few examples of saccate genera except *Remysporites* are present. Monolete or monocolpate grains are apparently absent. Evidently, the Drybrook spore florule has little in common with the well-diversified and rich spore complex described by Butterworth & Williams (1958) from the Limestone Coal Group and the Upper Limestone Group of the Scottish Lower Carboniferous. The spore content of the Oil Shale Group (Love, 1960) which is comparable with that of Butterworth & Williams is also considerably varied and apparently younger than the Drybrook spore florule. Our present knowledge of the microspore assemblages from horizons older than the Oil Shales is very incomplete. It is, however, interesting to mention that Knox (1959 : 92) reports the occurrence of 13 genera from the base of the Calciferous Sandstone Series. They are *Punctatisporites*, *Calamospora*, *Granulatisporites*, *Cyclogranisporites*, *Lophotriletes*, *Apiculatisporis*, *Planisporites*, *Microreticulatisporites*, *Cristatisporites*, *Reticulatisporites*, *Lycospora*, *Densosporites* and *Cirratriradites*. Ten out of the above genera are also present in our assemblage. On the whole the Drybrook assemblage of sporae dispersae and that of the base of the Calciferous Sandstone Series show a close relationship with one another. We are inclined to believe that the Drybrook spore florule, like that of Knox, indicates a horizon fairly low in the Mississippian and supports the macrofossil evidence. On the other hand from the palaeozoological and stratigraphical evidence several geologists including Welch & Trotter (1960 : 60) place the Drybrook beds much higher and consider that they are in the Upper Caninia Zone C_2S_1. The North Wales floras from the Lower Brown and Upper Black Limestone like the Drybrook Sandstone flora are associated with marine animal fossils and may possibly have been developed under different ecological or climatic conditions from those prevailing in other areas during the Lower Carboniferous and this might account for the difference in the floristic composition between them and floras of the same age in other parts.

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PLATE 19

Scutellocladus variabilis gen. et. sp. nov.

FIG. 1. Leafy branch with closely set leaf-bases. B.M., V.42433. Nat. size. Syntype.

Fig. 1*a*. Part of the same specimen. ×3.

FIG. 2. Small forking branch with leaves still attached showing the areas of attachment of the leaves with a longitudinal ridge representing the leaf trace. B.M., V.42538. ×3. Syntype.

FIG. 3. Dichotomously forking leafy branch. B.U. 800. Nat. size.

FIG. 4. Dichotomously forking branch showing leaf-scars with central punctiform scar. B.M., V.42558. ×4.

FIG. 5. Small leafy twig. The apical region of one branch is seen. B.M., V.42477. Nat. size.

FIG. 6. Smallest size of leafy branch found. U.G. Pb.3452. Nat. size.

Cf. *Stigmaria*

FIG. 7. Impression of the outer surface of an axis bearing a number of stigmarioid scars. B.M., V.42428. Nat. size.

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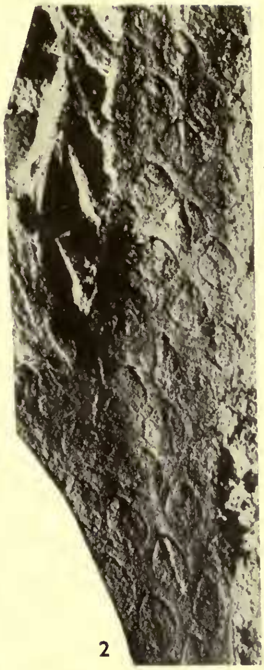

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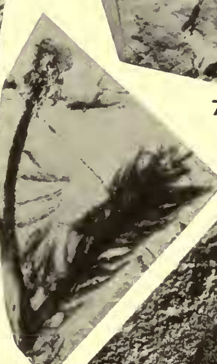

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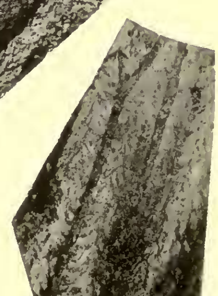

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LELE & WALTON

PLATE 20

All figures are natural size

Diplopteridium holdeni sp. nov.

FIG. 8. Specimen showing central part of a frond with remains of fertile rachis. B.M., V.42453. Holotype.

FIG. 9. Base of a frond with small basal pinnae. B.M., V.43004. Paratype.

FIG. 10. Part of a frond showing apparently inaequilateral pinnules on the pinnae. B.M., V.42487. Paratype.

FIG. 11. The two terminal portions of a frond. B.U. 804*a*.

FIG. 12. Parts of the two divisions of a frond showing clearly the form of the pinnae. B.M., V.42524.

FIG. 13. Part of the largest frond. Portions of its two divisions on the left and right and parts of presumably its fertile rachis (x) between. B.U. 804.

FIG. 14. Middle part of an apparently sterile frond. B.M., V.42474. Paratype.

FIG. 15. Parts of a frond with very slender ultimate segments. B.M., V.42457.

Sphenopteris obfalcata (Walton) n. comb.

FIG. 16. ?Main rachis of a frond with proximal parts of six subopposite primary pinnae· B,U. 803.

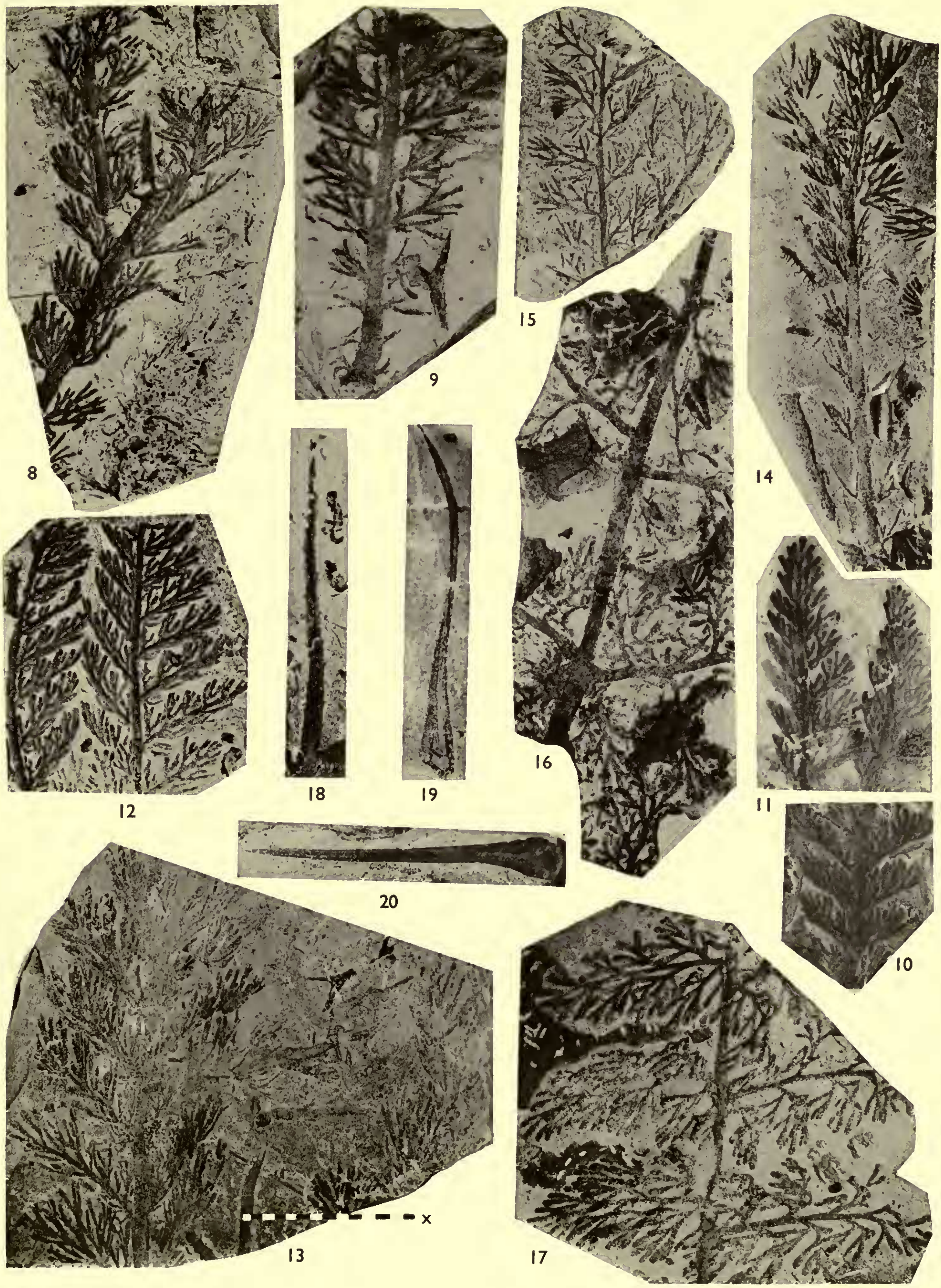
Fig. 17. Part of a frond to show form of pinnae and their ultimate divisions. B.M., V.42488.

Lepidophyllum cf. *fimbriatum* Kidston

FIG. 18. Distal part of a leaf with a single row of short hairs on each side. B.M., V.42516.

FIG. 19. Almost complete leaf showing expanded base. No hairs are evident. B.M., V.43442.

FIG. 20. Complete leaf showing acute apex. B.M., V.42531.



LELE & WALTON

PLATE 21

Sphenopteris cuneolata L. & H.

FIG. 21. Part of a frond with parts of nine pairs of pinnae. Lectotype ; B.U.801. Nat. size.

Archaeopteridium tschermaki (Stur) Kidston

FIG. 22. Parts of three pinnae. B.U.802. ×2.

Telangium sp.

FIGS. 23, 24, 25 and 26. Groups of fructifications which appear to consist of microsporangia attached to discs at the ends of slender rachides. 23, 24 B.U.802 and B.U.800 ; 25, 26 B.M., V.42435 and V.43443. ×3.

Calathiops sp.

FIG. 27. Fructification with a cupule *c*, probably ovuliferous, shown at *c*. B.M., V.42432. ×3.

FIG. 28. Fructification probably ovuliferous. B.U.802*a*. ×2.

FIG. 29. Cupule with numerous lobes. B.M., V.42478. ×2.

Sporae dispersae

(All figures are ×500. Locality and horizon same as for the macrofossils.)

FIGS. 30, 31. *Leiotriletes sphaerotriangulus* (Loose). V.43723, V.43705.

FIGS. 32–34. *Punctatisporites minutus* Kos. V.43721, V.43706, V.43707.

FIGS. 35–37. ? *Punctatisporites minutus* Kos. V.43706, V.43707, V.43713.

FIGS. 38–42. *Punctatisporites subobesus* sp. nov. (Holotype : Fig. 40). V.43700, V.43720, V.43701, V.43722, V.43726.

FIG. 43. *Punctatisporites* sp. V.43709.

LELE & WALTON

PLATE 22

All figures × 500

FIG. 44. *Calamospora* sp. cf. *C. mutabilis* (Loose) V.43707.
FIG. 45. *Granulatisporites tenuis* sp. nov. Holotype. V.43708.
FIG. 46. *Granulatisporites tenuis* sp. nov. V.43714.
FIGS. 47, 48. *Granulatisporites* sp. cf. *G. orbiculus* (Pot. & Kr.). V.43702, V.43708.
FIGS. 49–51. *Cyclogranisporites amplus* McGregor. V.43704, V.43721, V.43707.
FIG. 52. *Cyclogranisporites* sp. V.43705.
FIGS. 53–55.—*Planisporites minimus* McGregor. V.43705, V.43711, V.43712.
FIG. 56. *Planisporites* sp. cf. *granifer* (Ibr.). V.43724.
FIG. 57. *Verrucosisporites* sp. V.43716.
FIG. 58. *Camptotriletes* sp. V.43701.
FIG. 59. Cf. *Convolutispora* sp. V.43700.
FIGS. 60, 61. *Microreticulatisporites* cf. *cribellarius* (Horst). V.43710, V.43707.
FIGS. 62, 63. *Microreticulatisporites* spp. V.43703, V.43708.
FIG. 64. *Dictyotriletes* sp. V.43726.
FIG. 65. *Lycospora* cf. *bracteola* Butt. & Will. V.43707.
FIGS. 66–69. *Lycospora* spp. V.43710, V.43715, V.43708.
FIGS. 70, 71. *Anulatisporites anulatus* Pot. & Kr. V.43707.
FIG. 72. ? *Anulatisporites* sp. V.43724.

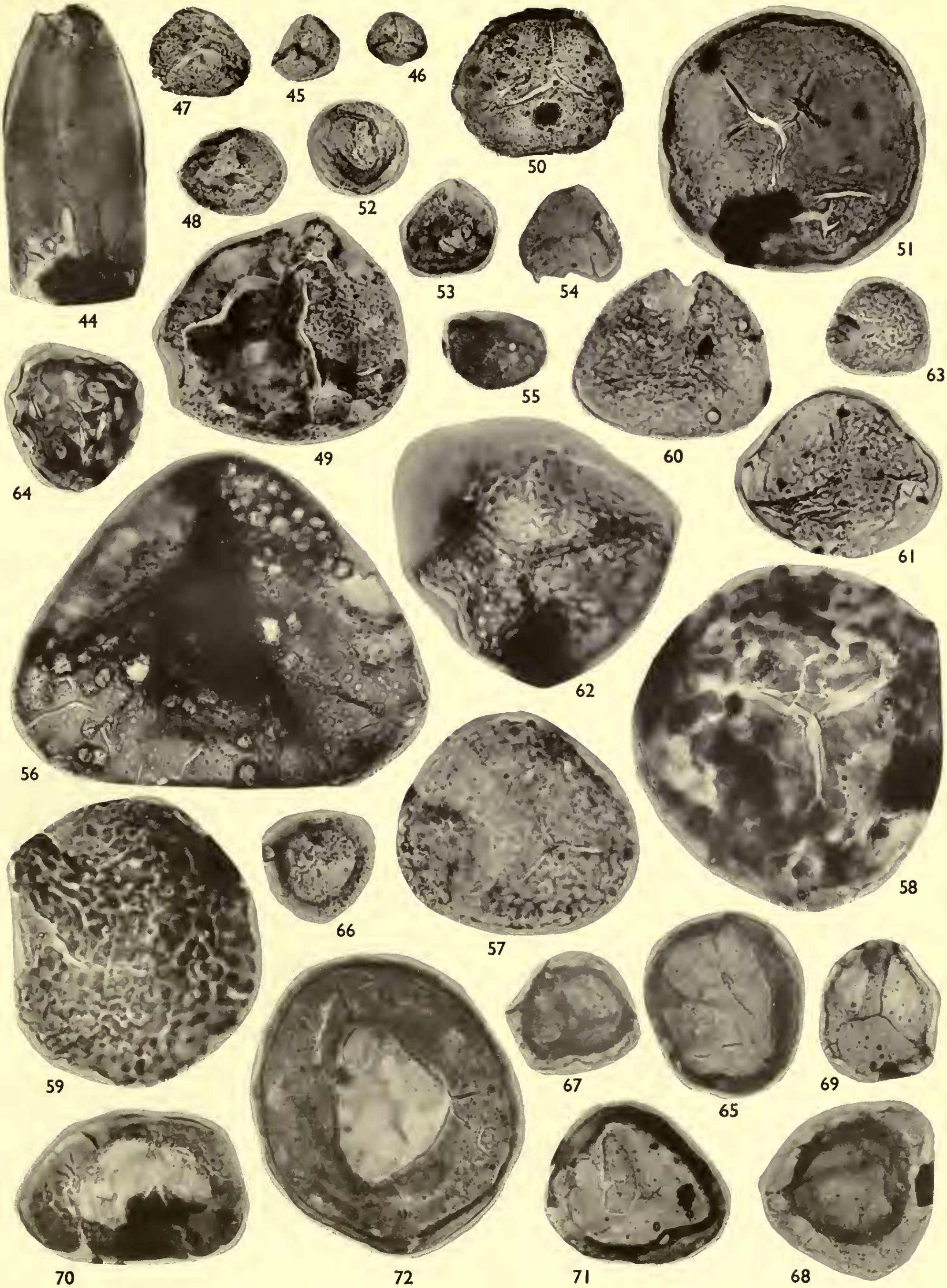

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PLATE 23

All figures ×500

FIG. 73. *Densosporites* sp. V.43720.

FIG. 74. Cf. *Cirratriradites* sp. V.43700.

FIG. 75. *Endosporites* sp. V.43727.

FIG. 76. *Remysporites drybrookensis* sp. nov. Holotype. V.43719.

FIGS. 77–81. *Remysporites drybrookensis* sp. nov. V.43725, V.43713, V.43728, V.43717, V.43718.

FIG. 82. Cf. *Remysporites* sp. V.43700.

FIGS. 83, 84. *Insertae sedis*. V.43705, V.43711.


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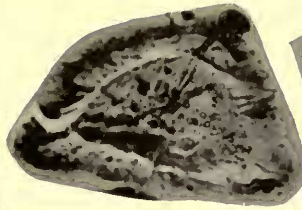
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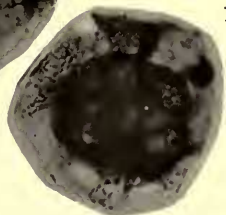
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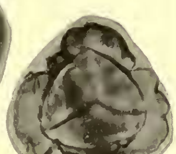
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